CALIFORNIA
ENERGY
COMMISSION

CLIMATE CHANGE AND CALIFORNIA

DRAFT STAFF REPORT

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EXECUTIVE SUMMARY

Climate change represents a significant risk to California as a result of a warming and increasingly variable climate. The signs of a global warming trend continue to become more evident and much of the scientific debate is now focused on expected rates at which future changes will occur. Rising temperatures and sea levels and changes in hydrological systems are threats to California's economy, public health, and environment.

In 1988 the California Legislature recognized that climate change could adversely affect the state and called for an assessment of impacts and identification of potential strategies. Since then California has inventoried its greenhouse gas emissions, improved energy efficiency and conservation, created a voluntary greenhouse gas registry, established ambitious goals for renewable energy, and is now preparing regulations to achieve reductions in greenhouse gas emissions from motor vehicles. While California has been a leader in climate change, more can be done to better prepare for an uncertain climate future and improve resiliency of the state's economy. Taking appropriate steps to address risks posed by climate change can help insure a more sustainable future and benefit the state's citizenry and natural and economic resources.

California needs a more comprehensive strategy to address climate change. Significant reductions of greenhouse gas emissions and adaptation to the causes resulting from these emissions relies upon both technological and behavioral changes. Decreasing the state's dependence on fossil fuels, the primary source of greenhouse gas emissions, will require integrated policies and short and long-term strategies. The feasibility, benefits, costs, and priority of climate change strategies need to be evaluated using a consistent life-cycle emissions approach. California must prepare to adapt to the impacts of climate change, efforts that will benefit from ongoing and new research to better understand and predict future changes in the state's climate. Climate change also needs to be reflected in critical state and local planning processes.

Finally, California should pursue partnerships with neighboring states and countries to jointly take leadership positions in addressing the challenges presented by global warming. Such partnerships can lead to the crafting of new and innovative solutions and provide a public process that is open to all interested stakeholders. Regional partnerships can lead to progress in transportation, energy efficiency, renewable energy and electricity generation, research and development, building and appliance energy efficiency, and greenhouse gas accounting through registries and improved emissions inventories.

CHAPTER 1: CLIMATE CHANGE AND CALIFORNIA

Change is happening to California's climate. The frequency of extreme climatic events worldwide indicates that climate variability may be on the rise and scientists predict global warming will significantly increase that variability in the future. California needs to develop a more comprehensive strategy to effectively and efficiently address a wide range of issues related to climate change risks, impacts, uncertainties, and opportunities. The purpose of this report is to provide the context for climate change in California, recognize past and ongoing activities related to this topic, identify strategies and recommend new measures to tackle the potential challenges the state faces with a changing and more variable climate.

There is little question that California's economy, populace, and natural resources are vulnerable to a number of adverse consequences that result from increased climate change and variability. The state can initiate new actions to address climate change while working to better understand the complexities of climate science. Responses to climate change can strengthen the economy and allow California to maintain a leadership role in worldwide efforts to address the challenges presented by global warming. The specific topics that will be discussed in this section include:

- What is the greenhouse effect?
- Evidence of climate change and vulnerability
- Action taken to address climate change
- Trends in California's GHG (GHG) emissions
- Strategies to reduce GHG emissions and adapt to future changes
- Strengthening the state's response to climate change

SIGNS OF A CHANGING CLIMATE:

Earlier melting of the Sierra snowpack

Continued and accelerated rise in sea level

More frequent and longer wet or dry periods

Increased number and spread of invasive species

EXAMPLES OF ADVERSE CONSEQUENCES:

- Reduced summer water supplies and increased agricultural water demand
- Rising demand for and spending on energy
- More frequent and intense wildfires
- Loss of low-lying wetlands and increased cost to protect beaches and coastal infrastructure

The signs of a significant global warming trend are increasingly evident, more visible at the high latitudes of the Earth's poles but detectible as well in the mid-latitudes and at the equator. Several regions are experiencing earlier onset of spring and less severe winters. While some evidence of change is qualitative or anecdotal, much of it is scientifically quantitative or empirical. Modern technologies allow the collection, storage, and processing of vast amounts of observational data related to the physical, chemical, biological and social systems of our planet. So what does this large increase in scientific data collection tell us about our atmosphere, oceans, landscapes and most importantly climate that we live in and come to expect each day?

Much of what these observations tell us is that the Earth's systems are complex and interrelated, from periodic oscillations of ocean currents to the role of airborne particles in cloud formation and atmospheric warming or cooling. The State of California and the federal government are committed to aggressive research programs designed to help us better understand natural versus human influences on our climate. Scientific uncertainty about the degree of human impact and the finer workings of these systems should not be a call for inaction outside of research, but rather a call for a diverse set of actions that match the magnitude of the stakes associated with a possible 2° F to 10° F (or more) increase in global average annual temperatures by the end of this century.

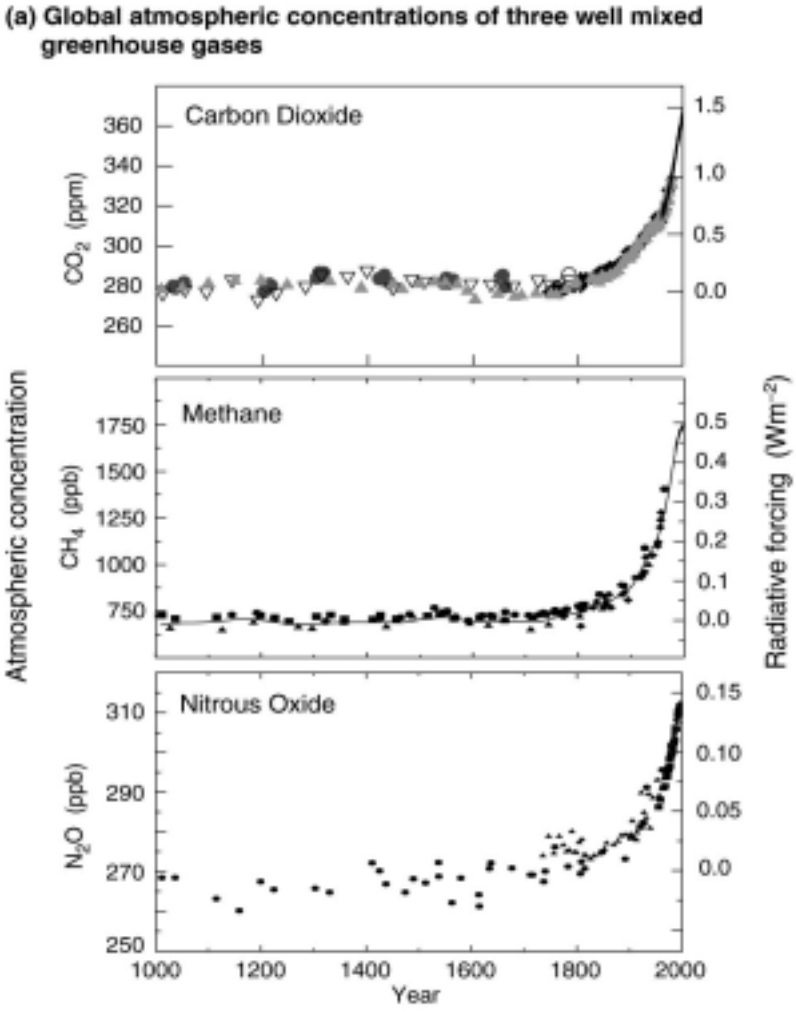
WHAT IS THE GREENHOUSE EFFECT?

One topic universally agreed upon by atmospheric scientists is the existence of a layer of gases surrounding the Earth that have the ability to trap heat. This phenomenon has been labeled the "greenhouse effect." These greenhouse gases (GHGs) have accumulated for millions of years and are essential to maintain temperatures on Earth that are suitable for humans and other living organisms. There are many types of GHGs, the most common being water vapor followed by gases such as carbon dioxide, methane, troposheric ozone, halocarbons (manmade compounds) and nitrous oxide. Certain GHGs such as carbon dioxide and methane have both natural and human-induced sources of emissions to the atmosphere. Other gases like the refrigerants in most motor vehicle air conditioners have only human-caused sources that contribute to the greenhouse effect. The term "radiative forcing" is used to describe a change in the balance between incoming solar radiation and outgoing infrared radiation. The addition of GHGs to the atmosphere traps a higher percentage of the outgoing infrared radiation, with some of the trapped radiation coming back toward the Earth's surface and creating the warming effect.

RISING LEVELS OF CARBON DIOXIDE AND OTHER GREENHOUSE GASES

The rapid increase of carbon dioxide levels in the atmosphere has been well documented over the last four decades and is generally not disputed. Controversies arise when scientists attempt to predict the rate at which this effect will increase global average temperatures and the relative importance of anthropogenic (human) sources of GHGs. Scientists have established a parallel relationship between increased CO_2 concentrations and changes in atmospheric temperature based upon several sources of information related to historical climates. After remaining relatively constant from 1000 to 1700, **Figure 1-1** shows CO_2 and two other prominent GHG concentrations began to rise sharply and have increased 30 percent since pre-industrial times.

Figure 1-1
Rising Concentrations of Greenhouse Gases



Rapid rise in concentrations of carbon dioxide, methane, and nitrous oxide is evident over the last one hundred and fifty years
Source: Climate Change 2001 - The Scientific Basis. The Intergovernmental Panel on Climate Change, 2001.

The primary source of human contributions to atmospheric concentrations of GHGs comes from the use of fossil fuel energy, to light our cities, power our factories, supply our industries, and fuel our transportation. The burning of gasoline, diesel, natural gas, and coal releases carbon dioxide as a byproduct of the combustion process. Another important source of GHG emissions is changes in land use and the removal of vegetation that had served as a reservoir of stored carbon. These rapid increases in GHGs coincide with the onset of the industrial era.

The Intergovernmental Panel on Climate Change (IPCC) is widely recognized as the most authoritative organization on the subject of climate change. The IPCC wrote in its 2001 scientific assessment:

> "[I]n the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations"[i] and that:
>
> "Anthropogenic greenhouse gases are likely to have made a significant and substantial contribution to the warming observed over the second half of the 20th century, possibly larger than the observed warming."[ii]

The U.S. Department of State's third national communication under the United Nations Framework Convention on Climate Change[iii] highlights a statement made by a distinguished committee of the National Research Council that concluded: "[h]uman-induced warming and associated sea level rises are expected to continue through the 21st century."[iv]

Recognizing the need to address California's largest contributing source to rising levels of GHGs in the atmosphere, Governor Gray Davis signed landmark legislation in July of 2002 drafted by Assemblymember Fran Pavley (AB 1493) and stated in his signing message:

> "This legislation is based four-square on sound science. The vast majority of scientists has concluded unequivocally that, if we don't reduce the emission of greenhouse gases, we'll disrupt our climate, foul the air and put our children and grandchildren at risk. Global warming is no longer a theory. It's an urgent reality. In time, every state – and, hopefully, every country – will act to protect future generations from the threat of global warming."[v]

The following chapter discusses evidence of a changing climate in California and provides examples of why the state is particularly at risk to various adverse consequences an increasingly warmer and more variable climate.

CHAPTER 2: EVIDENCE OF CLIMATE CHANGE AND VULNERABILITY

The climate of a particular region can change gradually along a particular path or trajectory. For example, night time temperatures can slowly warm on average or the total amount of annual rainfall can steadily increase or decrease. Separate from these types of gradual changes in a region's climate is the potential for increased variability of the climate. Examples of increased climate variability include longer drought or wet periods and increases in the frequency of extreme storm events. California has evidenced both a changing climate and increased variability of climate, particularly related to its water resources.

Put simply, California is vulnerable to potential adverse consequences of a warmer and more variable climate. The California Regional Assessment released in June 2002 provides a discussion of the susceptibility, vulnerability, and adaptability of the state's natural, economic, and social systems to potential future scenarios of climate change.[vi] This interdisciplinary team of authors state very clearly: "The climate is changing. Climate change and variability pose significant potential challenges to California's businesses, communities, and natural resource and ecological systems."[vii]

Currently, the most comprehensive source of information on global climate change is the IPCC's Third Assessment Report cited in the previous chapter. Based upon increasingly larger amounts of observational data and extensive modeling work, this report highlights expected changes that could be seen by the next four generations: average global temperature rises somewhere between 2° F and 10° F, longer durations of dry and wet periods, most areas of ice and snow cover decrease, and sea level rises between 0.3 foot and 3.0 feet.

CALIFORNIA'S WATER SYSTEMS FACE CHALLENGES

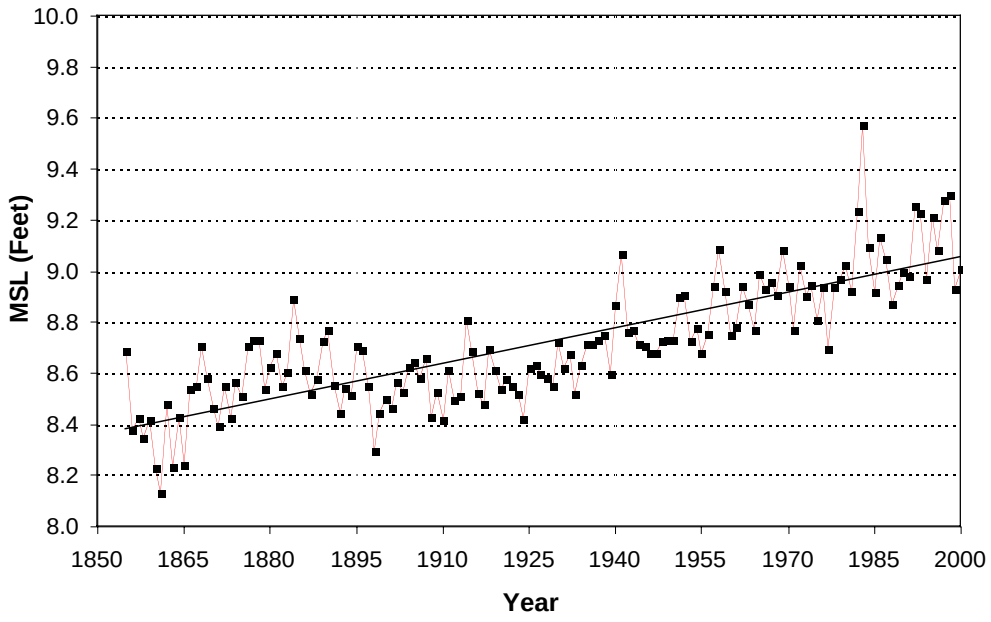
The California Department of Water Resources (DWR) recognizes that climate change and variability can have important consequences for the state's water resource systems. Warmer temperatures combined with increased variation in the timing and quantity of precipitation can significantly influence, for example, snow pack in the Sierra Nevada Mountains, water runoff patterns, water supply and demand, water temperatures, hydroelectric power production, wild fires, soil moisture and groundwater levels. Scientists face significant challenges when it comes to documenting increased climate variability and predicting changes in the frequency of extreme weather events. Record breaking events like the 1997-98 storm patterns in California highlighted the state's vulnerability to climate variability and the need to prepare for the possibility of increases in frequency of extreme weather events.

The climate factor of most significance to California's water systems is the timing and quantity of precipitation. Currently there is greater agreement amongst scientists that average

annual temperatures will rise in California, than agreement on expected changes in future precipitation patterns. The SCRIPPS Institution of Oceanography is partnering with the DWR and Public Interest Energy Research (PIER) Program of the California Energy Commission (Energy Commission) to improve data collection and regional climate modeling in an effort to reduce the uncertainty surrounding predictions of how precipitation patterns may change in California.

The DWR has information documenting sea levels that dates back to the mid-1800s from San Francisco Bay. The trend shown in **Figure 2-2** shows that sea level rise is less about increased variability (i.e., yearly peaks and troughs) and more about a gradual rise due to thermal expansion and additional contributions of freshwater. The approximately seven inch rise in sea level is expected to continue, if not at a faster rate, and when combined with possible increases in extreme storm events suggests that California's bays, deltas, and low-lying coastal areas are vulnerable to increased flooding events.

Figure 2-2
Sea Level Rises Seven Inches Since 1855



San Francisco Yearly Mean Sea Level (1855-2000)
Source: California Department of Water Resources, 2001

California's water flows from watersheds in the Sierra Nevada Mountains have an increasing proportion coming earlier in the calendar year. The DWR has information that dates back to the early 1900's regarding both the timing and volume of water flows within watersheds of the Sierra Nevada Mountains. The data shows that April through July flow volumes have steadily declined while January through March has increased over this period. The DWR

estimates these watersheds supply a total of 14 million acre-feet of freshwater on average or nearly 40 percent of California's net demand for agriculture and municipal uses. **Table 2-1** identifies the types of impacts expected to result from warmer temperatures and reduced snowpack in the Sierra Nevada Mountains. The DWR is evaluating these risks and considering adaptive measures as part of the state's planning process related to water resources.[viii]

Table 2-1
Vulnerability of California's Water Systems to Climate Change

Warmer average temperatures will result in:	• Snow levels moving to higher elevations, reduced spring snowmelt and earlier seasonal runoff • Higher winter runoff flows that cannot be stored due to the state's need to manage flood risk • Rising sea levels that combine with more severe storms to damage levees in the Sacramento-San Joaquin Delta and increase saltwater intrusion
Reduced snowpack in Sierra Mountains can lead to:	• Reduced annual hydroelectric power production • Lower total yearly freshwater yields • Lower summer reservoir water levels

If California's water resource systems face challenges from climate change and variability, so too will the state's agricultural sector. While agricultural production is potentially vulnerable to climate change risks associated with adverse water system impacts, this sector faces other risks that come with increasingly unpredictable variations in both temperature and precipitation. For example, increases in the frequency of extreme weather at inopportune times can cause significant declines in agricultural productivity.[ix]

SENSITIVITY AND VULNERABILITY OF CALIFORNIA'S ECOSYSTEMS

California has many "micro-climates" within its borders and a large number of plants and animals uniquely adapted to these climatic conditions. Highlighted by the state's large number of threatened or endangered species, these resources are exceptionally vulnerable to the effects of climate change and variability. While more difficult to model or predict smaller-scale regional climatic changes, it is clear that even gradual changes can impose added stress to the state's unique climate regimes, such as kelp forests along the central coast and redwood forests of the north and central coast.

Many areas of California are currently under siege by invasive non-native species and the vulnerability of these ecosystems to foreign invaders can only increase with the additional

stresses caused by climate change.[x] Current and future increases in climate change and variability pose both short-term and even greater long-term risks to biological diversity that exists within various ecosystems existing within California's borders.

CLIMATE CHANGE AND PUBLIC HEALTH CONCERNS

Climate change and variability can adversely affect human health, in both direct and indirect ways. While an assessment focused at the national level, many of the health outcomes described in *The Potential Health Impacts of Climate Variability and Change for the United States* are broadly applicable to California.[xi] This report identifies five areas of health concern. Increases in average temperatures and more frequent and intense heat waves can cause a greater number of heat-related illnesses and deaths. Thousands of people died in an August 2003 extended heat wave in France. Many that lost their lives prematurely were elderly people with no air conditioning and living alone. This calamity showed exactly how vulnerable an industrialized country can be to health risks associated with extreme climatic events.[xii]

More frequent and extreme weather events will increase physical dangers to people living in the affected areas. Rising temperatures and prolonged heat waves result in people using more electricity in the summer months, likely increasing fuel consumption and air pollution from power generation. Changing weather patterns and storm events can also affect water quality and increase the risks of a variety of water-borne diseases. Finally, changing climate patterns can lead to more favorable conditions for elevated cases of certain diseases such as Valley Fever, West Nile Virus, and Hantavirus. California's health care systems and capability for early detection help to reduce the risks associated with health-related consequences of climate change and variability.[xiii]

CHAPTER 3: ACTION TAKEN TO ADDRESS CLIMATE CHANGE

Many of the risks and impacts from climate change will be imposed upon the next generation of Californians. These risks are partly a function of choices made by previous generations, but increasingly are a function of action or inaction of decision makers today and tomorrow. The potential for climate change to diminish the natural resource endowment of future generations is significant and therefore a concern of the people and institutions of California and cause for appropriate action.

Climate change is at once a global and a local issue, reflected in actions by all levels of government and private organizations. Businesses are taking leadership positions and voluntarily cutting their GHG emissions. Local and state governments are responding with specific measures to cut emissions within their jurisdictions. The U.S. government has set a goal of reducing "GHG intensity"[xiv] by 18 percent over the next decade, potentially achievable by cutting emissions and increasing economic productivity.[xv] Partnerships of public and private organizations like the Prototype Carbon Fund are helping to make climate-friendly energy projects a greater reality in developing countries.[xvi]

Initial activities at the international level were solidified in 1992 with the United Nations Framework Convention on Climate Change (UNFCCC). This agreement established broad voluntary targets for GHG emission reductions to be achieved by the year 2000. This convention was followed by more specific reduction commitments for industrialized countries in the Kyoto Protocol, negotiated in 1997 in Japan. This protocol had 39 countries commit to specific GHG emission reduction targets based upon 1990 emission levels, to be achieved as an average over the 2008-2012 commitment period. As examples, Canada agreed to a six percent reduction below 1990 emission levels, the U.S. a seven percent, and the European Community an eight percent reduction. In early 2001 the U.S. withdrew from the process to ratify the Kyoto Protocol citing concerns related to impacts to the U.S. economy and lack of commitments from developing countries.

CALIFORNIA'S RESPONSE TO CLIMATE CHANGE

The California Legislature was one of the first to address concerns about climate change, when it passed a bill authored by Assemblyman Byron Sher in 1988. This legislation directed the Energy Commission to assess the likelihood of adverse consequences to the state and recommend strategies to mitigate those impacts. The Energy Commission prepared the first statewide inventory of GHG emissions as a staff report in 1990.[xvii] The first report to recommend climate change strategies was prepared by the Energy Commission in 1991 and both the GHG inventory and strategies were updated in a January 1998 report.[xviii] Workshops

were held in 1999 to review actions taken by business leaders and the status of climate science.

Legislation authored by Senator Byron Sher in 2000 led to creation of the California Climate Action Registry (Registry), a non-profit organization with the primary function of promoting voluntary annual reporting of GHG emissions by California entities. This legislation also directed the Energy Commission to update and maintain the statewide GHG emissions inventory, as well as identify and communicate mitigation strategies, technologies, and approaches that efficiently and equitably address climate change in California.

The Registry was launched in the Fall of 2002 and currently 35 participants from a broad spectrum of business and government have volunteered to assess and report their emissions. The State of California agrees to provide appropriate consideration of these certified emissions results in the future, when possible regulatory regimes may be implemented to reduce GHG emissions at the international, national, or state level. The Registry is working with its members to promote and document measures that reduce the participant's direct and indirect generation of GHG emissions.

Three bills were signed into law by Governor Davis in 2002 that will help California significantly reduce its contribution of GHGs to the atmosphere. Assemblymember Fran Pavley authored AB1493 (Chapter 200, Statutes of 2002) which directs the California Air Resources Board to adopt regulations "that achieve the maximum feasible and cost-effective reduction of GHG emissions from motor vehicles," providing a direct response to the state's largest source of GHG emissions.[xix] Senator Byron Sher authored two important bills signed into law in 2002 that will lead to GHG reductions. He drafted the renewables portfolio standard legislation that will achieve GHG reductions by increasing the state's reliance upon non-fossil fuel energy for production of electricity. His other piece of legislation calls upon the Registry to develop protocols that account for additional carbon stored in California's forests and landscapes, fostering management activities that reduce GHG emissions.

Several state agencies are actively working to reduce GHG emissions. The California Air Resources Board is currently developing regulations to achieve GHG emission reductions from motor vehicles built starting in 2009. The Department of General Services supports emissions reductions through efforts such as the "Driving Green Task Force." The Integrated Waste Management Board mitigates emissions through actions contained in the "Sustainable Building Implementation Plan." The departments of Water Resources (DWR), Forestry and Fire Protection, Food and Agriculture, and Transportation (Caltrans) all have activities underway to help California mitigate its GHG emission and better prepare for the expected outcomes of current and future changes in climate.

The Caltrans has a Director's Policy titled "Energy Efficiency and Conservation Policy." This policy calls for the incorporation of efficiency and conservation measures into transportation plans to minimize the use of fuel and other energy resources. The Director's Policy also promotes environmental stewardship, sustainable transportation, reductions in GHGs, and educational programs.

California's Energy Commission, Public Utilities Commission, and Power Authority have agreed to support cost-effective and environmentally sound energy strategies that will protect the public's health and safety, ensure quality of life, and take into account considerations of global climate change.[xx] The state's *Energy Action Plan* also recognizes that decreases in per capita electricity use, through energy conservation and efficiency, helps to minimize the need for new generation, reduces criteria and toxic air pollutants, and lowers California's emissions of GHGs.

The Energy Commission has several program activities linked to climate change including: energy efficiency, renewable energy, research and development, education and outreach, and interagency coordination on climate-related policies. The PIER Program has created a virtual research center, the California Climate Change Center (Center), to implement prioritized research projects. This Center will enhance on-going national and international research efforts regarding climate change to produce policy relevant California-specific studies. Currently, the Center has three components which are located at Scripps Institution of Oceanography, U.C. Berkeley, and the U.C. Office of the President. Scripps concentrates on scientific research related to climate variability and change. U.C. Berkeley research focuses on economic and social aspects of climate change. The U.C. Office of the President manages a competitive grant program related to climate change. The PIER Program intends to form a fourth component for the Center to research carbon sequestration in both terrestrial ecosystems and geological formations.

In August 2003, the U.S. Department of Energy selected the West Coast Regional Carbon Sequestration Partnership as one of seven regional groups to evaluate a range of carbon sequestration options. California and neighboring states will examine opportunities to capture and store CO_2, including issues related to transport, permitting, monitoring, verification, and public outreach. This regional partnership approach is a cooperative effort between federal, state, and private organizations and described as "the centerpiece" of federal efforts to understand the potential of carbon sequestration to help mitigate GHG emissions.

OTHERS ARE RESPONDING TO CLIMATE CHANGE

The mounting international effort to ratify the Kyoto Protocol has spurred political activity in the European Union (EU). Efforts within most member countries related to energy or environmental taxation are being combined with an EU-wide initiative to establish a GHG emission cap and emission trading system for large emitting industries. This "cap-and-trade" system is slated to begin in 2005. The United Kingdom started a voluntary emissions trading system in 2002, while Denmark instituted a mandatory cap-and-trade system for the electricity sector in 2001. Japan and Norway have plans to implement a GHG emission trading systems within the next few years. Both Denmark and Sweden have introduced energy taxes in efforts to lower energy demand and reduce GHG emissions. The United Kingdom has a carbon levy or fee on energy use applied to the business and the public sectors as an incentive to reduce emissions. Countries like Belgium, France, Ireland, and

Norway are all planning to introduce taxes on energy, carbon emissions, or fossil fuel consumption, all aimed at reducing the levels of GHG emissions.

Several U.S. states have set specific goals for reducing GHG emissions. New Jersey established a target of 3.5 percent below 1990 levels by 2005. Maine recently set a target of 10 percent below 1990 emissions by 2020. Six New England states and five Canadian provinces have together established a regional target of 10 percent below 1990 levels by the year 2020. The states of Oregon, New Hampshire, and Massachusetts have issued regulations pertaining to GHG emissions from their electricity sectors. Several states have work underway to establish GHG emission registries, all of which intend to coordinate with the Registry.

A number of states including California have established renewable portfolio standards such as Connecticut, Hawaii, Maine, Massachusetts, Nevada, and New York. **Table 3-1** shows the GHG emission reduction targets set by various states.

Table 3-1
State Commitments to Reduce Their GHG Emissions

Maine	10 percent below 1990 levels by 2020
New York	5 percent below 1990 levels by 2010 and 10 percent below 1990 levels by 2020
New Jersey	3.5 percent below 1990 levels by 2005
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont in cooperation with five Canadian Provinces	10 percent below 1990 by 2020

Local governments are also making commitments to reduce their GHG emissions. Currently, 139 cities across the U.S. have joined an International Council for Local Environmental Initiatives (ICLEI) campaign called Cities for Climate Protection. Several of California's largest cities are members of this campaign. Some of these cities have also agreed to inventory their GHG emissions each year as a participant in the Registry.[xxi] **Table 3-2** highlights some of the commitments made by California local governments to address climate change by cutting their GHG emissions.

Table 3-2
Cities Commit to Cutting GHG Emissions

Chula Vista	20 percent below 1990 levels by 2010
San Francisco	20 percent below 1990 levels by 2012
Oakland	15 percent below 1990 levels by 2010
Berkeley	15 percent below 1990 levels by 2010
San Jose	10 percent below 1990 levels by 2010
Los Angeles	30 percent below 1990 levels by 2010 (for municipal operations)

CORPORATIONS ARE SHOWING LEADERSHIP

Climate change is both a local and global issue. While impacts are and will be felt locally, the solutions must come from global cooperative efforts. Much of the industrialized international community has committed to some level of GHG emissions reduction, a sign of their concern over climate change. California businesses with linkages to international commerce are becoming increasingly aware of concerns about climate change, responsibility to reduce emissions, and related economic opportunities abroad. A variety of U.S. firms are taking action to reduce their GHG emissions and promote the development and use of low-carbon emitting technologies abroad. For more information on this topic, see the international energy market section of the ***Public Interest Energy Strategies Report***.

Business sector climate initiatives can range from companies making a commitment and publicizing their achievements to participation in organizations such as the Registry or the Chicago Climate Exchange, a pilot program for GHG emissions trading. Corporations such as DuPont, IBM, and Alcoa have all committed to significant GHG reductions and many of these companies are having their emission levels certified by an independent organization. Often companies find that cutting GHG emissions through energy efficiency measures turn what was perceived as a cost into a profit through reduced expenditures on energy.

Stockholder groups of large public corporations are beginning to ask for evidence that the company is thinking about its GHG emissions and developing plans to reduce this potentially important environmental liability in the future. The insurance industry is thinking about climate change, both from the damages side of extreme weather events to the corporate officer liability side of responsible management practices. **Table 3-3** is a list of diverse types of corporations that have committed to reducing their output of GHG emissions.

Table 3-3
Corporations Commit to GHG Reductions

Alcoa	25-50 percent reduction below 1990 by 2010
AEP	4 percent below 2000 by 2006
British Petroleum	10 percent below 1990 by 2012
DuPont	65 percent below 1990 by 2010
General Motors	10 percent below 2000 by 2005
IBM	63 percent below 1990 by 2005
International Paper	4 percent below 2000 for US emissions by 2006
Johnson & Johnson	7 percent below 1990 by 2010
Royal Dutch Shell	5 percent below 1990 by 2010
Toyota	5 percent below 1990 by 2005

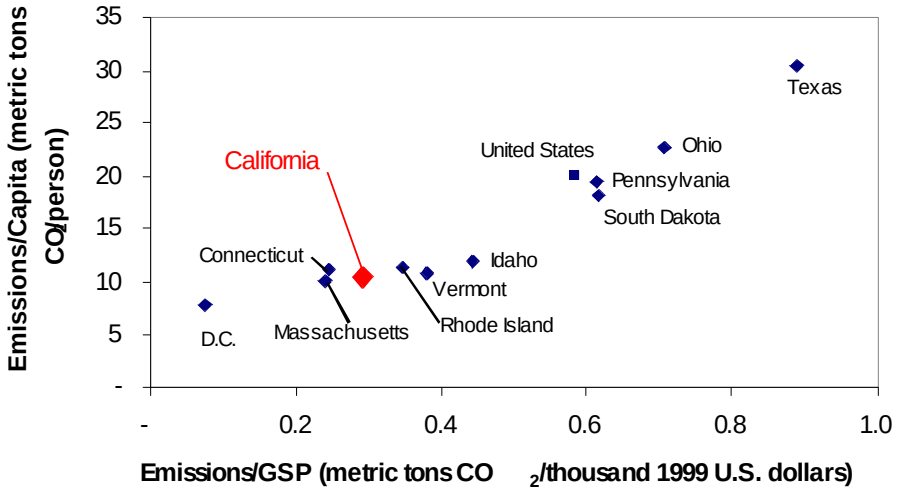
In California, approximately 25 non-governmental organizations have taken a leadership role in estimating and reporting their GHG emissions. They have voluntarily joined the Registry and now have the ability to accurately record the progress made in reducing their emissions of GHGs to the atmosphere.

CHAPTER 4: TRENDS IN CALIFORNIA'S GHG EMISSIONS

Emissions of GHGs are predominantly linked with fossil energy use. Interest in emission trends dates back to 1957 when a scientist named Roger Revelle highlighted the fact that humans were taking carbon out of long-term storage as coal, oil and natural gas, and returning it to the atmosphere and oceans at an increasingly rapid pace. California emits a large amount of GHGs to the atmosphere every year, second only to Texas in annual emissions within the fifty states. Taking into consideration the size of the state's population, economy, and geography, comparisons can be made more along efficiency lines by looking at emissions per capita and per dollar of gross state product. When taking into account the population and economic size of the state, Californian's emit significantly lower levels of GHGs than the average citizen of the U.S..

California emits a variety of GHGs to the atmosphere. In 1999, carbon dioxide accounted for 84% of state's GHG emissions. Methane accounted for 8%, nitrous oxide 6%, and various synthetic gases such as refrigerants reached 2% of total emissions. Shown in **Figure 4-1** is a comparison of statewide CO_2 emissions on a per person basis vertically and based upon size of the economy horizontally. Recognizing that many GHG compounds have a long lifespan in the atmosphere, it is important to monitor trends in total emissions by type of GHG, as well as monitor trends in emissions relative to factors such as population size and level of economic activity.

Figure 4-1
1999 CO_2 Emissions Based on Size of Population and Economy

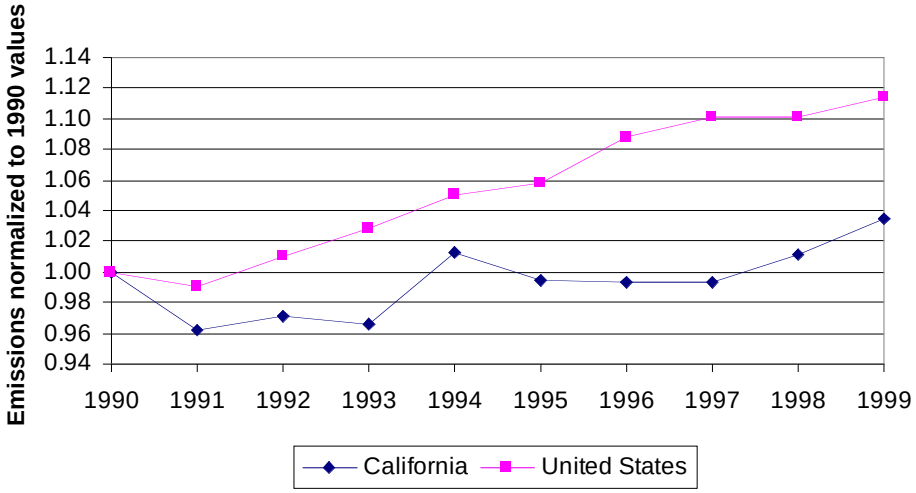


Few States Emit Less Greenhouse Gases than California on a Per Person Basis or a Gross State Economic Product Basis
Source: Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999. California Energy Commission, November 2002

Total emissions of GHGs in California rose slightly over the decade of the 1990s. The state's programs to promote air quality, numerous forms of energy efficiency, renewable sources of energy, and clean energy technologies all contributed to slower growth in GHG emissions relative to the rest of the country. Changes in the economy towards less energy intensive industries or activities also contributed to a slowed growth in emissions over this period.

The graphs in **Figure 4-2** compare growth in gross annual GHG emissions (not including net changes of carbon stored in vegetation) for the U.S. and California with 1990 as the base year. Emissions for the U.S. rose almost 12 percent over the decade, while gross emissions within California rose by less than 4 percent over the same period. A number of factors contributed to California's slower rise in GHG emissions including: growth of less energy intensive industries, stable per capita electricity consumption, energy efficiency and air quality policies, additional co-generation and renewable energy, and a slight increase in imported electricity.

Figure 4-2
Percent Change in Gross GHG Emissions: 1990-1999



Percentage growth in total United States GHG emissions was significantly higher between 1990 and 1999 than the growth of emissions in California
Source: Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999. California Energy Commission, November 2002

The trends in GHG emissions based upon changes in the size of California's economy and population are shown in **Figure 4-3** and **Figure 4-4**, respectively. The state's GHG emissions relative to economic output, one measure of GHG intensity, changed little during the first half of the decade and then declined in the latter half of the 1990s. California's growing economic output combined with the trend towards less energy-intensive industries helped bring about this decline in the state's GHG intensity. Annual emissions per person were lower in 1999 than levels at the beginning of the decade. The factors described above helped keep statewide GHG emissions from rising in proportion to increases in population over the decade of the 1990s.

Figure 4-3
California Emissions per Dollar of Gross State Product

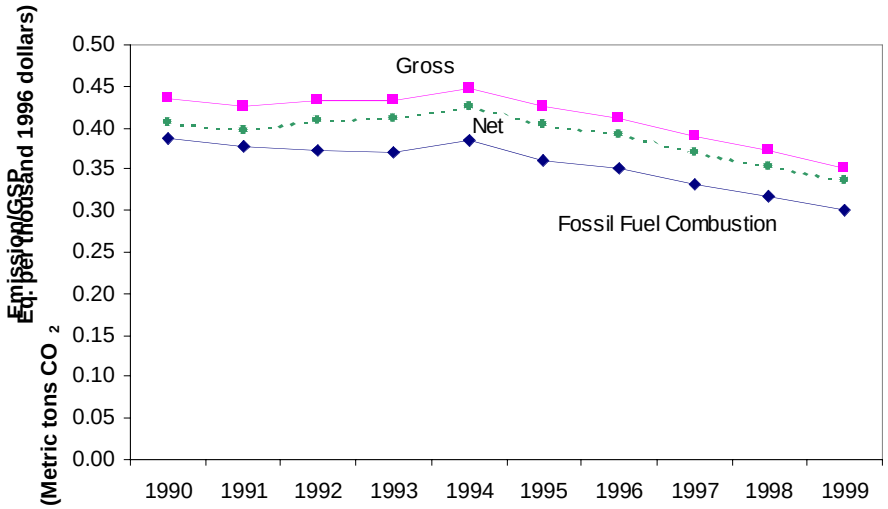
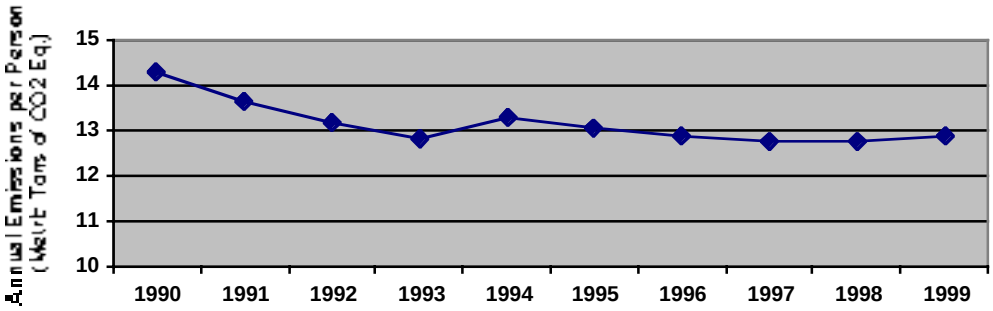


Figure 4-4
California GHG Emissions Per Person

The graph shows that GHG emissions per person living in California generally declined

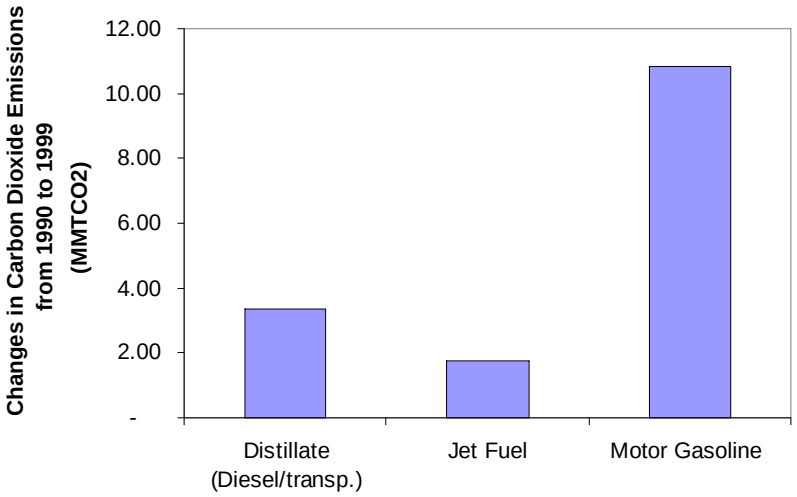


throughout the 1990s
Source: Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999. California Energy Commission, November 2002; and California Department of Finance, *Revised Historical City, County and State Population Estimates with 1990 and 2000 Census Counts*. March 2002.

Californians did not fare nearly as well in the 1990's when it came to GHG emissions from the transportation sector. Over this ten year period the state's emissions of carbon dioxide from motor fuels rose significantly, in large part a result of more vehicles spending more time each year on California's roads. The increase in CO_2 emissions from gasoline, distillate fuel, and jet fuel rose over the decade of the 1990s by 9.4 percent, 14.5 percent, and 4.5

percent respectively. **Figure 4-5** shows that CO_2 emissions from consumption of gasoline rose by approximately 11 million metric tons, a significant increase within a ten year period.

Figure 4-5
Million Metric Ton Increases in Transportation CO_2 Emissions: 1990-1999



More cars, trucks, and planes traveling more miles resulted in higher GHG emissions from California's transportation sector between 1990 and 1999
Source: Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999. California Energy Commission, November 2002

California's carbon dioxide emissions from the combustion of fossil fuels in 1999, the most recent year totals have been calculated by the Energy Commission, was dominated by the transportation sector (58 percent). Electricity production (16 percent) and industrial emissions (13 percent) followed in distant second and third places, with residential (9 percent) and commercial (4 percent) emissions of carbon dioxide from fossil energy sources representing even smaller fractions of total statewide CO_2 emissions.

Methane (CH_4) emissions in 1999 accounted for only 8 percent of total statewide GHG emissions after being weighted by its greater warming potential in the atmosphere (expressed in CO_2 equivalent). Agriculture and landfill operations are sources of a large percentage of the state's methane emissions. Fertilizer use in agriculture also contributes a high proportion of the nitrous oxide (N_2O) emissions in California, another high global warming potential gas but only 6 percent of 1999 statewide GHG emissions. The fastest growing class of GHGs is the synthetic or man-made halocarbon compounds, such as the hydroflorocarbons (HFCs) in motor vehicle air conditioning systems. At the end of 1999, these compounds totaled only 2 percent of statewide GHG emissions.

CHAPTER 5: STRATEGIES TO REDUCE GHG EMISSIONS AND ADAPT TO FUTURE CHANGES

Climate change mitigation and adaptation strategies can be grouped within three broad categories. The first category contains strategies in the transportation sector, the state's largest source of GHG emissions and a sector subject to a variety of adverse consequences from increased climate change and variability. The second category contains strategies linked to the electricity sector, including renewable energy and energy efficiency. The final category is used to highlight several strategies in other sectors of California's economy or where specific actions are expected to lead to a beneficial climate change outcome. Examples within this last category include adaptation strategies, carbon sequestration, utilization of emerging GHG markets, research and development, and public education. While consumption of fossil energy is the state's primary source of emissions, a variety of opportunities to mitigate GHG emissions exist outside of energy production and use in California.

TRANSPORTATION SECTOR GHG REDUCTION STRATEGIES

California has a variety of programs aimed at reducing criteria air pollutants emitted in the transportation sector, many of which also reduce GHG emissions. Policies and programs to promote a cleaner and more efficient transportation system can be found at the California Air Resources Board, the Energy Commission, the Caltrans, and the Department of General Services.

The state can build upon these programs to achieve greater reductions in GHG emissions. Decisions we make today that have an influence on land uses, number of miles people travel in motor vehicles, vehicle technologies, and other transportation-related policies will determine the measure of progress towards a cleaner and more sustainable transportation system. In addition to reducing GHG emissions, a more sustainable transportation system should provide for more efficient use of transportation resources, reduced dependency on fossil fuels, provide greater energy security, improve mobility and travel options, and lead to more livable communities.

Reducing California's Dependence on Petroleum Fuels

As directed by legislation passed in 2000 (AB 2076) the Energy Commission and California Air Resources Board have developed and adopted recommendations to the Governor and

Legislature on a strategy to reduce petroleum consumption. The strategy includes: 1) a statewide goal to reduce the on-road demand for gasoline and diesel to a level that is 15 percent below the 2003 demand by the year 2020, 2) a recommendation for the federal government to adopt standards that would double the on-road fuel economy of new passenger cars, light trucks, and sport utility vehicles, and 3) a goal to increase the use of non-petroleum fuels to 20 percent and 30 percent of on-road energy demand by 2020 and 2030, respectively.[xxii]

The development of the recommended goals is based upon an analysis of the net changes in costs and benefits expected to result from a variety of energy efficiency options and fuel substitution options (non-petroleum fuels). The analysis includes the additional expenses for different technologies and fuels, the value of net changes in environmental impacts, including estimates of avoided damages from climate change, and certain avoided costs associated with petroleum dependency. These costs and benefits were combined for each option and the relative merits of options expressed in the form of net benefit values. This type of analysis allows for an overall petroleum reduction strategy that is created from a portfolio of petroleum reduction options, each with positive net benefits.

Armed with these analyses and recommendations to reduce petroleum consumption, the Legislature and Governor have a foundation for establishing specific policies consistent with the proposed recommendations. To guide and direct state institutions, the Legislature and Governor can enact legislation that codifies in statute the petroleum reduction goals. This action would then set in motion activities to implement the recommendations and new work focused upon achievement of the goals.

Since a majority of the state's GHG emissions come from the transportation sector's combustion of fossil fuels, a reduction in the rate of consumption of gasoline and diesel will lead directly to decreases in GHG emissions. If the proposed petroleum reduction strategy is implemented, on-road energy demand in 2020 could be approximately 30 percent below the business-as-usual demand forecast. The use of an individual average light-duty vehicle in this scenario would result in a GHG footprint that is about one-half the size of a current average gasoline vehicle. Beyond 2020, the demand for gasoline and diesel can be held constant through the use of non-petroleum fuels such as ethanol, hydrogen in fuel cells, natural gas fuels, and possibly biodiesel fuels. Thus, the expected impact on reduced GHG emissions of achieving the goals to reduce petroleum dependence would be significant.

Implementing the Motor Vehicle GHG Standards Legislation

The Governor's signing of AB 1493 (Pavley) in July of 2002 put in motion a unique effort to mitigate California's largest source of GHG - motor vehicles. This landmark legislation can provide a significant amount of reductions in GHG emissions below a business-as-usual scenario without such GHG standards. These emission standards will apply to new vehicles starting with the 2009 model year. This particular regulatory approach to GHG mitigation

will also draw upon market-based incentives through the granting of credits for early actions that cut GHG emissions from new motor vehicles.

Additional Transportation Climate Change Strategies

There is a need to explicitly address GHG emissions and energy efficiency in most statewide and regional transportation planning processes. Policies that provide resources and incentives can be designed to ensure that climate change issues are addressed in these plans. There are ways to continue to "green" the state and local government motor vehicle fleets and lead the way to a cleaner and more energy efficient transportation sector in California. A broad range of strategies can be utilized to slow the rate of increase in vehicle miles traveled. A focused transportation research program combined with greater efforts to educate the public about the linkages between transportation and climate change, can lead to reductions in greenhouse emissions from this largest and growing source. However, achieving significant GHG reductions in the transportation sector will require a relatively long period of time.

Specific measures the state should consider as part of a comprehensive strategy to reduce California's transportation sector GHG emissions include:

- Partnering with local governments and managers of large private fleets to reduce the purchase costs of commercially available hybrid-electric vehicles
- Actions that assist labeling and marketing of more fuel-efficient replacement tires for motor vehicles
- Expand the use of electrified stalls at truck stops to reduce emissions and fuel consumption from truck idling during rest stops
- Participate in the commercialization of cost-effective grid-connected hybrid-electric vehicles

California's transportation sector is a growing source of GHG emissions. Evaluation and implementation of the above mentioned measures and other transportation strategies will be an essential component of an effective plan to reduce GHG emissions within the state. Transportation strategies to mitigate GHG emissions will be explored further in future editions of the Integrated Energy Policy Report.

ELECTRICITY SECTOR STRATEGIES TO ADDRESS CLIMATE CHANGE

Great progress has been made over several decades to improve energy efficiency and provide cleaner sources of electricity, both efforts that help reduce the state's GHG emissions. More remains to be done. GHGs associated with the production of electricity consumed in California is the state's second largest source behind transportation sector emissions. In other parts of the country emissions from electricity generation is much closer to levels emitted

within their transportation sector, a fact reflective of both Californian's propensity to drive and lack of in-state coal-fired power generation. Because a significant amount of electricity is imported from other states, Californians are indirectly responsible for electricity sector GHG emissions within the neighboring states that export electricity to California.

Californians have managed to keep their per capita consumption of electricity at a stable level, increasing one tenth of one percent on average in the 1990s. Residents consume less electricity on a per person basis than all other states. Based upon existing policies and programs, it is anticipated that per capita consumption of electricity will remain stable over the next decade.[xxiii] By contrast, national consumption per person is expected to increase at a rate several times higher than California. While electricity consumption on a per person basis may be low, power generation continues to be a large source of GHG emissions.

California has the first state-sponsored research program on climate change in the nation, funded by electricity ratepayers in the form of a public goods charge. The PIER Program brings new energy services and products to the marketplace and helps create statewide environmental and economic benefits including reduction of GHG emissions. Recognizing that power plants are a major contributor to GHG emissions, the PIER Program has funded a significant amount of research to assess the potential impacts of climate change in California, as well as develop research plans to assist in the evaluation of GHG mitigation and adaptation strategies for the state.[xxiv]

It is possible for electricity generators to capture and store CO_2, but the ability to do so remains costly for most power producers. The Energy Commission has recently partnered with the Department of Forestry and Fire Protection, the Department of Food and Agriculture, agencies from neighboring states, and private sector organizations to form the West Coast Regional Carbon Sequestration Partnership. The focus of this partnership will be regional opportunities to capture CO_2 from processes such as electricity generation, transport it, store it in geological or terrestrial reservoirs, monitor and verify the long-term storage, and conduct public outreach on the potential value of carbon sequestration alternatives to mitigate GHG emissions.

Energy Efficiency and Conservation Reduce GHG Emissions

Carbon dioxide is emitted when fossil fuels are burned in California's industrial, residential, commercial, and agricultural sectors, either directly or indirectly through consumption of electricity generated from fossil fuels. Improved energy efficiency characterizes these sectors over the past decade. Annual carbon dioxide emissions from these combined sectors from 1990 to 1999 have remained relatively constant, even as the state's population and gross economic output rose 13 and 28 percent respectively. California's ability to reduce GHG emissions while maintaining economic growth will require intensified efforts to increase energy efficiency and conservation in these sectors. The state can look inward and start by requiring the use of sustainable energy and environmental designs in all of its buildings.

As detailed in Chapter 3 of the ***Public Interest Energy Strategies Report***, demand-side-management (DSM) continues to hold great potential for reducing energy use and the associated reductions in GHG emissions. DSM activities include increasing energy efficiency, conservation, and electricity demand or load management. Energy efficiency improvements can be discovered and acted upon in many ways. In all cases, efficiency improvements that reduce energy demand help cut GHG emissions to the extent that less fossil fuel is consumed in the overall supply of energy within California. Changes in behavior that lead to energy conservation both improves some type of efficiency (e.g., annual amount of energy to heat or cool a house), saves the end-user of energy money, and reduces GHG emissions.

The shifting of electricity demand to off-peak periods through price signals or other measures can lead to important reductions in GHG emissions. These measures can lead to cuts in GHG emissions because of the potential to utilize more efficient power generation units than some units currently serving peak load electricity demand. These measures can also lead to cuts in GHG emissions when conservation rather than load shifting results. California has made significant progress in recent years when it comes to reducing peak load demand for electricity.

Initiatives that increase energy efficiency help reduce energy expenditures in our economy, making businesses more competitive and allowing consumers to save money and live comfortably. Although efficiency programs and policies to reduce growth in demand for electricity and natural gas have resulted in significant consumer savings, research shows that additional cost-effective savings remain to be achieved. California's *Energy Action Plan* calls for the appropriate use of price signals, improved building and appliance energy efficiencies, increased conservation programs and other incentives to reduce the demand for electricity. These types of efforts can guide California along a path towards greater competitiveness, an improved environment, and reduced emissions of GHGs.

Renewable Sources of Energy

Renewable energy has the potential to be a cornerstone of policies that aim to reduce GHG emissions. Renewable sources of energy can replace traditional fossil fuels used for electricity generation, as well as reduce the state's reliance upon petroleum in the transportation sector. Examples of renewable energy include solar, geothermal, wind, biomass to energy, landfill gases, and hydroelectric facilities (California statute requires hydroelectric facilities to be 30 MW or smaller in size to qualify as renewable). By reducing the state's dependence on imported energy from other states or countries, increased reliance upon the state's renewable sources of energy helps reduce GHG emissions and helps protect the economy and citizenry from fossil energy price spikes. A comprehensive discussion of renewable energy in California can be found in Chapter 5 of the ***Public Interest Energy Strategies Report***.

Creating a diverse supply of renewable energy sources increases the resiliency of the state's energy supply portfolio. In addition to potential displacement of GHG emissions from fossil fuel generated electricity, renewable sources can often be deployed as small distributed units

(e.g., photovoltaics on urban rooftops or small-scale wind turbines for rural locations) and thereby reduce transmission losses and demand on the transmission system. Certain renewable sources, such as biomass from forests to reduce fire risks or municipal waste bound for landfills, serve multiple societal goals besides helping reduce emissions of GHGs. With the passage of the renewable portfolio standard legislation drafted by Senator Sher in 2002, California requires electricity retail sellers to obtain 20 percent of their power from renewable sources by the year 2017. The state's *Energy Action Plan* calls for a more ambitious timeline to achieve the goal of 20 percent renewable powered generation by the year 2010.

The emphasis on renewable power is in large part due to the multiple types of benefits that result from expanded uses of renewable resources. Utilization of additional renewable resources for electricity generation can reduce California's reliance upon natural gas. Most forms of renewable energy also reduce public health risks and environmental impacts associated with emissions of nitrogen oxides, as well as particulate matter and sulfur dioxide from imported electricity generated from coal. Reaching the mandated target for renewable energy by 2017 could reduce CO_2 emissions by 38,000,000 tons from electricity generation within in the Western Electricity Coordinating Council between 2004 and 2013. The accelerated renewable energy goal is estimated to produce a more significant reduction of CO_2 at 62,000,000 tons. For some context, this latter amount is equivalent to the CO_2 emissions resulting from the annual driving of more than 6 million automobiles in California.[xxv]

While California has aggressive policies and programs to promote use of renewable energy resources, there are additional measures the state can take to support increased utilization of renewable energy resources for electricity generation. California can partner with its neighboring states and countries to encourage the development and transmission of renewable sources of electricity generation. A regional partnership could make significant progress in developing an efficient renewable power tracking and certification program. In collaboration with others or independently, California can increase its effort to research, development, and deploy renewable projects, and promote demand for renewable energy as an alternative to electricity generated from fossil fuels.

Regulatory frameworks at the federal, state, and local levels that encourage long-term financial commitments to the development of renewable resources and long-term contracts for electricity generated from renewable energy resources will be key factors. An example is the need to develop transmission infrastructure to support large-scale development of renewable projects. The state can increase demand for renewable energy by providing informational materials to raise consumer awareness of renewable energy and by supporting green pricing programs that are over and above the mandatory requirements of retail sellers to provide renewable energy.

Western states should work to improve the operating efficiency of the Pacific Coast transmission system. Finally, agencies from western states should investigate the potential benefits of biomass-to-energy facilities to address the growing safety concerns associated

with wild fires. These and other strategies to develop additional renewable energy resources will be evaluated further in the next Integrated Energy Policy Report.

Mechanisms to Reduce Electricity Sector GHG Emissions

It is important to acknowledge up front: 1) in-state electricity generation is relatively efficient on a GHG basis, 2) GHG emissions from electricity generation are less than emissions from the transportation sector, 3) California has aggressive renewable energy policies and programs in place that promote improved air quality and GHG emissions reductions, and 4) the following discussion does not reflect advocacy for any particular mechanism.

A variety of mechanisms are currently employed outside of California that lead to reduced GHG emissions associated with the production of electricity. A number of additional measures are being designed or tested and scheduled to begin in the near future. Mandatory reporting of GHG emissions is common for large emitters within the electricity sectors of many developed countries. The Energy Commission should consider required reporting of GHG emissions as part its facility permitting process. The European Union will launch its GHG emissions trading program in 2005. Individual countries within Europe also use energy or carbon taxes to provide financial incentives to reduce GHG emissions within their electricity sectors. A voluntary project that includes power generators, the Chicago Climate Exchange, recently completed its rulebook for the launch of its pilot GHG emissions trading program.

Several states including Massachusetts, Oregon and New Hampshire established generation efficiency benchmarks for CO_2 emissions from power plants. These benchmarks are typically based upon the best available technologies to reduce GHG emissions and can be updated as new technologies are developed and marketed. Oregon combines two mechanisms to reduce GHGs from electricity generation, efficiency benchmarks and a requirement to offset a portion of GHG emissions from new sources of power generation. Offsets can be achieved by funding or implementing projects that reduce atmospheric concentrations of GHGs.

In addition to efficiency benchmarks and required offset projects, a reduction mechanism receiving considerable attention is the “cap-and-trade” system. One connection between these mechanisms is the use of benchmarks as a key factor in determining feasible GHG emission caps. In a cap-and-trade system, a set quantity of emissions permits is allocated to emitters of GHGs and then entities are allowed to buy and sell their permits to cover their actual emissions. Those entities with lower costs of cutting emissions can reduce more than required and sell excess permits to those facing higher costs to reduce. The states of New York, Connecticut, Vermont, New Hampshire, Delaware, Maine, New Jersey, Pennsylvania, Massachusetts, and Rhode Island have agreed to develop a regional cap-and-trade system for CO_2 emissions within their electricity generation sectors.

The 1990 Clean Air Act Amendments authorized various forms of emission trading systems. The federal Environmental Protection Agency concluded in 2001 that successful trading

systems had been in operation for several years and that such systems can be applied to a wide variety of pollution sources. One example of a successful cap-and-trade system is the Acid Rain Program's marketable pollution allowance scheme with sulfur dioxide emissions from electric utilities in the northeast. This was initiated in 1995 and helped reduce annual emissions by 4 million tons and contributed to reductions of the acid content of rainfall by 25 percent.[xxvi]

OTHER CLIMATE CHANGE STRATEGIES

As noted earlier, the number of ideas on how to address global warming or climate change is rapidly expanding. Proposals can vary from changing the diet of cows to reduce their emissions of methane, to harnessing the tidal energy of oceans to replace fossil fuel electricity generation. Provided in this next section are examples of activities that could help California reduce GHG emissions or mitigate the more deleterious affects of climate change. These and other climate change strategies will be evaluated and discussed in greater detail in future productions of the Integrated Energy Policy Report.

Adaptation Measures to Lessen Impact of Future Changes

California needs to adapt to the expected effects of climate change. Without a comprehensive adaptation strategy, there will likely be significant short- and long-term economic and ecological losses resulting from climate changes within the state. Investments in adaptive measures can be appropriately scaled to the magnitude of the particular risk and the degree of certainty regarding the expected adverse climate outcome. Future damages resulting from climate change and variability can be reduced significantly by anticipation, observation, analysis, and planning.

The potential costs attributable to various adaptation strategies can range from little to no-cost measures on the low end and well into the billions of dollars on the high end. Examples of expensive adaptations might include significant enhancements to the state's levee system and reservoir construction to increase water storage. Some adaptive measures can generate net societal benefits regardless of mitigating climate change. Actions that increase California's ability to cope with the uncertainties of climate change can also help in dealing with existing threats to natural resource systems (e.g., current frequency of droughts, fires, and floods). Implementation of appropriately designed adaptation strategies can provide greater security for the standard of living of citizens while minimizing the social, environmental, and economic disruptions likely to result from climate changes associated with past, current, and future levels of GHG emissions.

Improving the state's capacity to operate its complex water management system in the face of a more variable climate will be a key part of California's adaptation strategy to climate change. Agencies are currently investigating the implications of climate change and sea level rise for restoration and levee enhancement programs. The state should produce a systematic

review and evaluation of all major multi-purpose reservoirs for water supply and flood control in view of the potential effects of climate change, particularly 100 and 200 year storm events, on monthly reservoir inflows. Development of more detailed hydrology and operational studies of the whole Central Valley system, including upstream reservoirs, will be needed for quantitative estimates of the effects of climate change.

Research efforts should concentrate on estimating the costs and benefits, as well as possible collateral effects of adaptation strategies. The state can significantly improve monitoring of hydrologic parameters, information that can document the degree and rate of change for planning purposes. Modeling and forecasting tools should be improved and used for water management, with a particular focus on water supply, precipitation, snow level and runoff changes, and potential impacts on the water infrastructure. The state should initiate and monitor changes in agricultural and forest management practices focused on changing the timing of planting, harvesting, and other management activities such as crop switching to reduce life-cycle GHG emissions while maintaining productivity. Efforts to improve the management of California's coastal zone should focus on slowing or phasing-out of development in coastal areas and incorporating adaptation options into coastal zone management. Finally, research on the vulnerabilities of California's natural ecosystems to climate change and variability should be supported.

California has the potential to sequester or store additional amounts of carbon in its forests, agricultural soils, and geological formations. Carbon sequestration typically involves the capture and secure storage of GHGs that would otherwise have been emitted to or remain in the atmosphere. California's farmers have the ability to store more carbon in their soils. Forest management practices can be used to consume more carbon dioxide and retain carbon stocks for longer periods of time. These types of activities often produce important collateral or co-benefits, such as improved soil and water quality, restoration of degraded ecosystems, increased crop productivity, and enhanced oil recovery. The West Coast Regional Carbon Sequestration Partnership has recently been formed and funded to identify new methods of storing additional carbon in terrestrial landscapes and geological formations within the region.

The Energy Commission in partnership with the Department of Forestry and Fire Protection and the Department of Food and Agriculture are working to improve methods of establishing an extensive inventory of carbon stored within California's landscapes. Techniques are being developed which improve the ability to quantify changes in amount of carbon stored and opportunities for additional carbon sequestration. This type of program should promote long-rotation silviculture on public and private forest lands and accelerate the aforestation of urban and abandoned agricultural areas. Other strategies might include aggressive reforestation of public and private lands historically burned by wildfire, and the inclusion of carbon sequestration potential as one criterion used to select acquisitions or conservation easements by government agencies. Finally, protocols to accurately and cost-effectively measure sequestered carbon are being developed by the California Climate Action Registry and could pave the way to additional carbon sequestration from the sale of emission reduction credits by forestland owners.

Improve Ability to Predict California's Changing Climate

The ability to anticipate future changes in California's climate, model the consequences of those changes to the state's economy, environment, society and then design policies in light of expected outcomes before they occur is critical to successful adaptation. California will need an investment strategy for adaptation to climate change that evolves over time with the arrival of new information on potential risks. Choices must be made regarding the types, timing, and level of effort towards adaptive measures. Information to support these decisions requires an analytical capability that is based upon extensive observations, superior data management and quality control, and state-of-the-art modeling specific to California. Creating an improved ability to detect climatic changes is vital to predicting future changes. Western states should increase efforts to coordinate the collection and sharing of climate-related data and other information necessary to predict regional changes in climate.

The Energy Commission recognizes the importance of building a robust analytical framework that allows decision-makers to test proposed climate change programs and policies for both technical efficacy and cost-effectiveness. The PIER Program has developed a series of climate change research roadmaps that include efforts to improve the state's ability to analyze various strategies to mitigate GHG emissions and implement adaptive measures to lessen the adverse consequences of expected changes in climate.[xxvii]

A majority of the state's strategic planning efforts need to consider and incorporate, where appropriate, climate change as a part of planning for the future. The state's Transportation Plan and Water Plan now consider issues related to climate change and GHG emissions. Coordination across various state agencies is essential to the effective development and implementation of a comprehensive adaptation strategy for climate change. Broad participation by potentially affected agencies is needed to build the framework for a comprehensive approach to climate change risk assessments and design adaptive strategies that minimize impacts to current and future generations of Californians.

Develop, Commercialize, and Export Clean Energy Technologies

For nearly twenty-five years, California has been a "proving ground" for new energy technology, advances in energy efficiency, and the use of renewable energy resources. California's energy policies, energy efficiency standards, economic incentives and research investments established the foundation for this technology leadership and the practical installation of clean energy projects in the marketplace. As a result of California's clean energy accomplishments, the state enjoys direct economic and environmental benefits. Over this timeframe, a significant new energy industry has emerged. This industry is comprised of equipment manufacturers, project developers, engineering firms and energy consultants involved in wind power, geothermal, solar and biomass energy technology, energy efficiency projects, cogeneration and combined heat and power systems, as well as non-petroleum

transportation fuels and technologies. California now represents between 20 percent and 80 percent of the U.S. industry for these categories of energy technology.

These clean energy technologies have a common attribute in that they improve air quality but also avoid or reduce GHG emissions. Consequently, the potential market for clean energy development is expected to increase as California adds GHG emission reductions to state policy objectives. Quantitative goals set for California's building and appliance efficiency standards, the renewable energy incentives and portfolio standard, and reduced dependence on petroleum in the transportation sector will stimulate domestic GHG emission reductions. Increasing demand for energy in the developing world, coupled with opportunities for countries under the Kyoto Protocol to pay for a portion of their GHG reductions by investing in developing countries, create a rapidly growing market for emission reductions. The firm Point Carbon maintains a database of emissions transactions that exceeded 280 trades by September of 2002.[xxviii]

California can facilitate trade in these clean energy technologies through a variety of mechanisms. The Energy Commission's Energy Technology Export Program has stimulated approximately $500 million in California export sales of energy efficiency, renewable energy and cogeneration technology and project services in the international marketplace. Facilitating GHG emission reduction credits from these current and future international projects will increase the state's knowledge of and ability to establish GHG reduction mechanisms and secure economic value for future reductions that come from California projects. This effort can enhance the development of domestic California energy projects and help maintain the state's technology leadership. The Energy Commission can also explore new connections between state and international government policies, investment sources, and techniques that will enhance California's efforts to reduce GHG emissions and promote domestic economic activity.

Shift Demand Towards Goods and Services With Less GHGs

The State of California has a large toolbox from which to draw upon in its effort to help consumers, including state agencies and local governments, consider the implications for GHG emissions and climate change. Many tools rely upon market mechanisms to shift demand towards processes, services, and products that meet consumer and producer needs or desires but with lower GHG emissions. These mechanisms create new demand, new economic opportunities, and the potential to strengthen California's economy.

Climate change strategies that shift consumer demand can be designed to compliment existing energy efficiency, renewable energy, and petroleum reduction measures that currently help California mitigate its emissions of GHGs. Economists have long recognized that market systems do not fully incorporate external costs such as air and water pollution, traffic congestion, and GHG emissions. Several state agencies have the ability to evaluate and implement a set of new actions that lead their primary constituencies to more fully consider current and future costs likely to be imposed by climate change and variability. It is

through an integrated set of measures to shift demand that the state can be most efficient in creating incentives for companies and consumers to reduce their impact on the atmosphere and take the steps necessary to adequately adapt to future climate changes.

A large body of economics research and writing exists on the subject of climate policy and the efficient use of incentives to influence consumer and producer behavior.[xxix] One example of a commonly used and often economically efficient tool is the application of a fee based upon the GHG contribution of a particular emissions source, such as fossil fuels. The proceeds or revenues from such fees can be returned, in part, to the energy user with a portion also used to invest in GHG reduction or adaptation measures. This type of demand shifting measure extends the logic underlying the current surcharge on electricity production to the consumption of fossil fuels that result in emissions of GHGs.

A second example would be the use of rebates and fees to encourage consumer purchases of the more energy efficient vehicles within a particular vehicle class or category. Another tool being tested within the transportation sector is Pay-At-The-Pump (PATP) and Pay-As-You-Drive (PAYD) insurance. These approaches to motor vehicle insurance hold the potential to improve insurance rates and reduce GHG emissions. Both PATP and PAYD insurance convert a relatively fixed cost of insurance (i.e., a set premium for a given period of time) into a variable cost that is based upon the amount of driving. In the case of PATP, a portion of insurance would be paid through a surcharge on gasoline, while a PAYD system would charge vehicle owners a per-mile fee or a fee based on time spent driving. In either case, these approaches to insurance can provide incentives for drivers to reduce their fuel consumption and miles traveled and thereby reduce emissions. PATP has the added benefit of making all drivers pay for some degree of insurance, compensating insured motorists for the liability created by uninsured motorists.

CHAPTER 6: STRENGTHENING THE STATE'S RESPONSE TO CLIMATE CHANGE

California has been successful in reducing its GHG intensity by combining a growing economy and population with a proportionately lower increase in GHG emissions. Several important climate change mitigation and adaptation efforts are currently underway within the state. Additional steps can be taken to promote new strategies that lead to increasingly more effective, efficient, and equitable climate change solutions for California.

The following set of recommendations is not limited to energy-related climate change issues. To date, California has not attempted to quantify the feasible range of GHG emission reductions or the reduction in risk and impacts of potential adaptation measures. Further, the state has limited information on the range of expected benefits and costs of climate policies, either in isolation or in combination. The relevant state agencies should collaborate on the quantification of feasibility, benefits, and costs associated with a set of prioritized strategies to address the challenges of climate change in California.

PURSUE OPPORTUNITIES FOR REGIONAL PARTNERSHIPS AND CLIMATE ACTION PLANNING

There are several distinct advantages of a regional approach to addressing the challenges presented by increased climate change and variability. Cooperation at the regional level has the ability to significantly increase consistency in state-level climate change policies. Greater consistency in policies is particularly of value for measures that have important ramifications beyond the borders, individual states, or provinces. For example, climate policy mechanisms such as combined purchasing power to improve transportation energy efficiency of member's fleets will benefit from a partnership that increases market size as a buyer. A west coast partnership could create the first system of emission-free truck stops along the Interstate 5 corridor that spans the distance between Canada and Mexico.

Regional partnerships can produce a more coherent voice supporting air quality and climate-friendly policies at the federal level such as higher fuel economy of new motor vehicles and greater energy efficiency requirements or fewer waivers for buildings and major appliances. Cooperation at the regional level can help standardize GHG accounting protocols and the formation of regional registries can serve as the testing-grounds for improved accounting procedures at the federal and international levels. Efforts such as the West Coast Regional Carbon Sequestration Partnership can draw upon the existing expertise and resources of

members to significantly extend research, development, and demonstration opportunities relative to actions taken as an individual organization.

Six Northeastern U.S. states have partnered with five Eastern Canadian provinces to reduce air pollutants including GHGs. Together these governments developed a regional climate change action plan in August 2001. In their plan members acknowledge the importance of reversing the global trend towards rising emissions and rapidly increasing concentrations of GHGs in the atmosphere. The partners describe common goals when stating "[S]pecifically, the plan presents a set of near-term options for our region that would help protect the climate, reduce GHG emissions and other pollutants, cut energy demands, and promote future job growth by harnessing sustainable energy resources and advanced technologies."[xxx] More recently ten Eastern U.S. states have agreed to design and implement a regional cap-and-trade system for GHG emissions within their electricity generation sectors.

A partnership between California and its neighboring states and countries has the opportunity to create solutions to climate change that are uniquely suited to the region. Innovative approaches can be designed that tap the potential of both market-based and regulatory mechanisms to improve the efficiency and effectiveness of each member's response. Regional efforts to increase transmission efficiency throughout the western electricity grid or promote the development, transmission, and tracking of renewable energy sources are measures that address climate risks while providing an array of co-benefits such as improved grid reliability and reduced dependence upon imported fossil fuels.

ENHANCE CAPABILITY TO EVALUATE CLIMATE CHANGE STRATEGIES AND POLICIES

The ability to compare relative advantages and disadvantages of climate change policies is dependent upon a sound analytical framework for the analyses. Climate policy measures should be evaluated based upon detailed information of California's economy. The state has available to it a broad range of climate policy instruments, many of which can be used in combination to achieve overall policy objectives. Recognizing that GHGs emitted outside of California's boarders contribute equally to atmospheric concentrations, evaluations of climate policy should include "life-cycle analyses" that capture all of the expected changes in GHGs resulting from a particular policy or set of policies.

The Energy Commission and other state departments, boards, and commissions should work to establish a common analytical framework for the quantitative evaluation of a myriad of climate change policies, programs, and actions. New analytical tools and models need to be developed. Enhanced climate policy analysis capabilities at state agencies should compliment the existing capabilities within California's universities and national laboratories.

Improve Methods to Inventory GHG Emissions and Reductions

The statewide GHG inventory provides an essential means of monitoring progress that results from various GHG reduction policies and programs. While California's statewide GHG inventory is a ground breaking effort, it can nonetheless be improved upon by developing new approaches to estimating several difficult to quantify GHG sources, as well as collecting new information that is currently not available for a more accurate assessment.

California should follow the federal government's example and generate an updated inventory of GHG emissions each year. Future efforts could also provide analysis and discussion of the key sources of uncertainty within the inventory and identify potential solutions to reduce the causes of uncertainty in the statewide emissions estimates. The state should continue to work with various types of organizations keenly focused in sound GHG emissions accounting, including federal and state agencies, interested local governments, California businesses, and a wide spectrum of international organizations. A sound GHG accounting system is a necessary foundation for emerging GHG markets that fund or trade emission reductions.

Evaluate Past, Present, and New Climate Policies and Strategies

California has a long history of policies and programs that improve air quality and reduce GHG emissions. With the exception of energy savings that result from policies to promote efficiency, the state does not have a similar history of quantifying the GHG reductions associated with past measures. One essential building block for developing a comprehensive climate change strategy is a thorough understanding of what has already been tried and how well it worked.

Energy Efficiency Policies Reduce GHG Emissions

"By reducing the demand for electricity during the 1990s, these savings helped to dampen the increasing trend in California's CO_2 emissions between 1990 and 1999. Savings from energy conservation programs, including electricity savings, in 1999 relative to 1990 are estimated at about 7.1 million metric tons of CO_2 equivalent."

Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999; California Energy Commission, November 2002, page 181.

California needs to establish a consistent and scientifically rigorous analytical framework to evaluate climate policies. The impact of GHG emissions are largely independent of either location or time emitted (their influence is global and lifespan long), so an analytical framework based upon life-cycle analyses is most appropriate for climate policy analyses.

The state has access to or can readily obtain the necessary tools, databases, and skilled staff to conduct depth evaluations of how past air quality and energy policies have contributed to cuts in GHG emissions. While challenging because often multiple factors lead to changes in emissions, performing such evaluations will assist efforts to quantify expected reductions from current and future climate change policies. The U.S. Environmental Protection Agency produced a report using a streamlined life-cycle analysis approach to quantify GHG implications of solid waste management measures designed to reduce waste at the source and promote recycling.[xxxi] Consistent use of this type of framework (streamlined or full) is needed to effectively evaluate a range of policies that target reductions of important sources of GHG emissions in California.

PROMOTE PARTICIPATION IN EMERGING GLOBAL GHG REDUCTION MARKETS

In light of the fact that the U.S. withdrew from the process to ratify the Kyoto Protocol in 2001, California's success in reducing GHG emissions may in large part depend on new state policy mechanisms and the ability of California corporations, government agencies and other entities to secure the financial asset value of those reductions. Knowledge of the financial asset value is based on quantification of the emission reductions that result from individual clean energy technology projects and other specific actions that reduce or avoid GHG emissions. Most of the existing experience in these transactions originates in Europe, although developing countries offer opportunities for cross border emission credit trading.

A handful of consulting firms in the U.S. also have developed expertise in international GHG emissions credit trading. Furthermore, the outcomes of industry-specific protocols needed in California to quantify project-based GHG emission reductions could be enhanced and accelerated if the state explores the applicability of a variety of mechanisms that exist outside of California. It is recommended that the Energy Commission gather information on the economic and financial stimulus for various GHG emission reduction mechanisms such as emission credit trading, cap-and-trade systems, permit trading, and GHG registries. An aspect of this analysis should include quantification of the financial asset value of specific clean energy technologies, GHG reduction actions, and how this quantification might enhance the development of industry-specific protocols.

In conducting this work the Energy Commission should undertake information sharing efforts and possible alliances with other U.S. states, the federal government, foreign governments and international organizations. Pilot programs to test various mechanisms should be considered, such as exploring a cross-border emission trading system for the contiguous California – Baja Mexico region.

INCREASE PUBLIC EDUCATION & OUTREACH EFFORTS ON CLIMATE CHANGE

One result of California's energy crisis was a dramatic illustration of how public education and outreach activities can have a significant impact on people's behavior. Continued efforts to inform consumers about the choices they can make to conserve energy and save money will also have a significant effect on GHG emission reductions. State agencies can provide valuable information that helps individuals make the connection between their consumption choices, GHG emissions, and the risks California faces with global climate change. The Energy Commission and California Air Resources Board currently provide the public with information about climate change, but more can be done with this type of strategy to help Californian's lessen their contribution of GHGs to the atmosphere.

In addition, a focused effort to identify and describe the expected consequences of climate change will enable Californian's to better adapt by making informed choices. There is ample opportunity to increase people's understanding of the types of climate change benefits that can be gained in aggregate by their efforts to conserve energy in the home, during commutes to and from work, or through a broad range of actions that can lead to emissions reductions. The education and outreach effort should be broad-based and multi-media. It should target numerous audiences from the business community, to school systems, local governments, and individual households.

END NOTES

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[iii] *U.S. Climate Action Report-2002*. U.S. Department of State. May 2002.

[iv] *Climate Change Science: An Analysis of Some Key Questions*. National Research Council, Committee on the Science of Climate Change. National Academy Press, Washington, D.C. 2001.

[v] For more information on AB1493 implementation see: http://www.arb.ca.gov/cc/cc.htm

[vi] *The Potential Consequences of Climate Variability and Change for California*. June 2002. A report of the California Regional Assessment Group, for the U.S. Global Change Research Program. See: http://www.usgcrp.gov/usgcrp/nacc/california.htm

[vii] *The Potential Consequences of Climate Variability and Change for California*. June 2002. A report of the California Regional Assessment Group, for the U.S. Global Change Research Program. Executive Summary. Page 1.

[viii] Find out more about the state's water planning process at: http://www.waterplan.water.ca.gov/b160/indexb160.html

[ix] *The Potential Consequences of Climate Variability and Change for California*. June 2002. A report of the California Regional Assessment Group, for the U.S. Global Change Research Program. Page 4-3-19.

[x] For more information see*: Confronting Climate Change in California: Ecological Impacts on the Golden State*. A report of the Union of Concerned Scientists and the Ecological Society of America. November, 1999.

[xi] Patz, Jonathan A., Michael A. McGeehin, Susan M. Bernard, Kristie L. Ebi, Paul R. Epstein, Anne Grambsch, Duane J. Gubler, Paul Reiter, Isabell Romieu, Joan B. Rose, Jonathan M. Samet, and Juli Trtanj. *The Potential Health Impacts of Climate Variability and Change for the United States: Executive Summary of the Report of the Health Sector of the U.S. National Assessment,* Environmental Health Perspectives, Volume 108, Number 4, April 2000.

[xii] *Heat Death Toll Forces a Shocked France to Question Itself*. John Tagliabue, The New York Times. August 20, 2003.

[xiii] For more information on climate change and public health visit the following website: http://www.jhu.edu/~climate/

[xiv] "Greenhouse gas intensity" is a measure of GHG emissions per unit of some other factor, typically economic output quantified as dollars of Gross Domestic Product.

[xv] Bush Administration climate change policy. February 14, 2002. See: http://www.state.gov/g/oes/climate/

[xvi] Learn more about the Prototype Carbon Fund at: http://prototypecarbonfund.org/router.cfm?Page=Home

[xvii] *1988 Inventory of California Greenhouse Gas Emissions*. California Energy Commission Final Staff Report. October 1990.

[xviii] *1997 Global Climate Change Report: Greenhouse Gas Emissions Reductions Strategies for California*. California Energy Commission. January 1998. http://www.energy.ca.gov/global_climate_change/documents/97_report.html

[xix] For more information on AB1493 implementation see: http://www.arb.ca.gov/cc/cc.htm

[xx] *Energy Action Plan*. California Energy Commission, California Utilities Commission, California Power Authority. May 8, 2003. Available online at: http://www.energy.ca.gov/2003_energy_action_plan/

[xxi] For more information on the California Climate Action Registry see: http://www.climateregistry.org

[xxii] Strategies to reduce California's dependence on petroleum can be found at the following location: http://www.energy.ca.gov/fuels/petroleum_dependence/documents/index.html

[xxiii] See: *Public Interest Energy Strategies Report*. California Energy Commission. August 8, 2003, page 25.

[xxiv] For additional information on PIER Program's climate change research plan go to: http://www.energy.ca.gov/pier/reports/500-03-025fs.html

[xxv] Estimate is based upon the following assumptions: 20 lbs CO_2/gallon, 20 miles/gallon, 20,000 miles/vehicle-year. For additional information about renewables and CO_2 see: *Public Interest Energy Strategies Report*. California Energy Commission. August 8, 2003, page 96.

[xxvi] *The United States Experience with Economic Incentives for Protecting the Environment.* National Center for Environmental Economics, U.S. Environmental Protection Agency. January 2001. Pages 67-88.

[xxvii] For additional information on the Energy Commission's climate change research visit: http://www.energy.ca.gov/pier/energy/index.html

[xxviii] See Point Carbon's web site at: http://www.pointcarbon.com/article.php?articleID=1959.

[xxix] For an example of this literature, see: *The Economics of Climate Policy*. Charles D. Kolstad and Michael Toman. Resources for the Future discussion paper. June 2001.

[xxx] *New England Governors/Eastern Candian Premiers - Climate Action Plan 2001*. The Committee on the Environment and the Northeast International Committee on Energy of the Conference of New England Governors and Eastern Canadian Premiers. August 2001. Page 2.

[xxxi] *Solid Waste Management and Greenhouse Gases – A Life-Cycle Assessment of Emissions and Sinks*. 2nd Edition. U.S. Environmental Protection Agency. May 2002.